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LOADING EFFECTS OF FISH FARMING WITH NET CAGES ON COASTAL WATERS - CAN IT BE REDUCED?

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Fish farming is one of the basic industries which, in recent years, has developed very rapidly in Finland. In 1982, the production of rainbow trout for consumption was 6.3 million kg and the total production for 1983 might even exceed seven million kg. In addition, a number of expansion plans and permit applications for new plants are presently in progress. The growth in farming of the rainbow trout has increased considerably in the last couple of years, particularly in marine areas. The focus of marine farming has, above all, been concentrated to the archipelagic sea but also to some other areas, among them the marine area outside Kuivaniemi. The favourable farming conditions in the sea as compared to those in the lake area are clearly evident from the fact that, although the part of the total area of farming basins occupied by net cages only amounts to approximately one fourth, the rainbow trout that those cages produce amounts to over fifty procent of the total production.

It is not likely that any clear limits on the growth of fish farming in marine areas will be apparent in the near future. The farming of rainbow trout for export is most successful in brackish water. The farming of marine salmon in addition to rainbow trout seems to be a further possibility.

The discussions about the environmental impact of fish farming which have been conducted in the case of lake areas have now been expanded to include the plants in the archipelago as well. There is probably not any doubt about the fact that fish farming in itself has a fertilizing effect on the water environment. On the other hand, the damage due to these effects, or the amount and nature of the damage caused by fish farming in the marine area as a whole, appear to be confusingly unclear. Nevertheless, press reports have presented positive statements about water pollution on one hand and about increased fish hauls as a result of fish farming on the other.

Confusion can equally be noticed in the actions of the water control authorities. On one hand, the permit applications are in a majority of cases left completely unattended; on the other hand, there is no clear conception of the nature and amount of damages. In supervisory directive nr 39 of the Water Administration, a limit for the size of farming plants in brackish water is recommended (a yearly production of 40-50 tons), a limit which can not be exceeded without special permission from a water court. This is 2-3 times higher than the corresponding limits in the lake area.

Research aiming to reduce the environmental effects of fish farming has already been conducted for several years through the Wildlife and Fisheries Research Institute, the Water Administration and some private fish farmers. The focus of the investigations has been centered on finding a solution to the problems in the lake area. The Water Administration alone has concentrated on the marine area, in particular on the development of methods to demonstrate the environmental effects of the farms.

If, during the next couple of years, it proves impossible to effectively limit the environmental effects of fish farming, then it is obvious that fish farmers will encounter an increasing resistance on the part of authorities and other water utilizers. A decrease in the harmful effects is, however, not only necessary because of pressures from authorities and shore dwellers. If no measures are taken, the risk remains that fertilization of the water environment in the archipelago grows to damaging proportions and possibly even impairs the productivity conditions for the fish farms themselves (see f.inst. Braaten & Boge 1983).

Loading effects on the water environment

The loading effects caused by fish farming consist of waste products from the metabolism of the fish as well as of waste feed. The former is not particularly foreign to the water environment; on the contrary. The changes caused by the breathing metabolism of the fish are relatively quickly balanced, when the proportions of oxygen and carbon dioxide restore their equilibrium with the corresponding atmospheric pressure. The rolling of the sea speeds up the process.

During the energy metabolism of the fish and the consequent breaking down of proteins, nitrogen is released which the fish actively secretes through the gills in the form of ammonia. There is also a surplus of phosphorus. Nitrogen and phosphorus are important nutritive substances for plants and therefore essential to the entire ecological water system. They are in effect so-called minimum factors in our waters, which means that a lack of these substances limits the production of algae and thereby the fertility of the entire water course.

Phosphorus is always the main limiting factor in Finnish lakes but the situation becomes slightly more complicated in the marine areas. Along the coast of the Gulf of Bothnia, a strong blooming peak in the algae during spring-time can produce a situation, where nitrogen replaces phosphorus as a minimum factor (Ala-Saarela 1978). Careful investigations in the Gulf of Finland have conclusively proven that nitrogen there is the main minimum factor for the production of algae. In certain cases, the growth of plant plankton is limited by other factors besides a lack of the main nutritive substances (winter conditions), or by both nutritive substances at the same time (Tamminen 1983). Consequently, it is not possible to apply directly the same models to watercourses in brackish water as are used in the lake area in order to determine the size of the permissible or the "dangerous" loading effects (see f.inst. Nyroos 1977, Vollenweider 1968). The impact of fish farming on brackish water should be clarified through accurate "in situ"-measurements of primary production and algae tests in order to establish, unequivocally, the size of the harmful loading effects, that is, the size of the loading which to an undesirable extent alters the nature of the archipelago and the living conditions of its flora and fauna.

The size of the loading effects

The loading effect caused by a fish farm has been measured by the farm's discharge of solid substances, nitrogen and phosphorus, as well as the biochemical oxygen demand of the discharge. The earth embankment used in farms in the inland lake area acts as a sedimentation basin in which sludge collects on the bottom. In spite of this, thorough investigation work (f.inst. Kaunismaa &

Bagge 1983) has established that its loading effects highly conform with the total loading effect, which has been accurately measured by means of substance equilibrium tests (f.inst. Selänne et al. 1983, Eskelinen 1983).

The variation in loading effects is presented in Table 1. If dry feed is used, the loading effects from net basin plants should not differ from these values.

Table 1. Loading effects from fish farming, expressed in g per consumed kg of feed and produced kg of fish (dry feed).

	g/kg feed	g/kg fish
Solid substance	80-280	110-520
Nitrogen	37- 48	51- 86
Phosphorus	4.7-10.8	7.1-18.4

The use of fresh feed is, in general, completely non-exist nt in the lake area. On the other hand, cut-up Baltic herring, sprats and smelts are extensively used as feed in the marine area. There are diverging opinions with regard to the extent of the loading effects caused by fresh feed. Foreign investigations have consistently maintained, that the loading effects caused by fresh feed are larger, approximately twice as large as the effects caused by dry feed (f.inst. Vandkvalitetsinstituttet 1976)*). This is, however, not necessarily applicable to Finnish conditions. Lappalainen et al.(1974), in their substance equilibrium tests, arrived at a considerably lower loading effect from fresh feed than from dry feed. In Finland, cut-up or even

*) The Danish Water Quality Institute

whole fish is used instead of ground fish and/or ground slaughter-house offals, which means that the nutritive content of the waste feed hardly exceeds the corresponding value for dry feed.

Theoretically, the matter could be summed up in the following way:

According to this theoretical calculation, the loading effects of fresh feed would not necessarily be greater than that of an average dry feed. On the other hand, a more "non-polluting" quality of dry feed would result in lesser loading effects than would fresh feed.

Decrease in the loading effects

To protect waters, fish farms can in practice take three important measures: 1) lower the proportion of nutritive substances in the feed, 2) improve the feed coefficient , 3) collect and treat the resulting sludge in order to prevent its content of nutrient salts from mixing with the water.

The importance of various factors in decreasing the loading effects of farming with net cages in brackish water can be estimated by means of the following mathematical example:

Although the calculation is theoretical, it makes possible the confirmation of two points: the use of fresh feed does not necessarily entail a loading of the sea with nutritive salts to the same high degree as does the use of dry feed. This especially applies to nitrogen with a loading effect which, calculated theoretically for fresh feed, seems to amount to only one fifth of that of dry feed. Secondly, the collection of sludge , a process

for which no one as yet has found a functioning technical solution, is a rather meaningless measure, especially with regard to the loading effects of nitrogen.

The uptake by fish of phosphorus and nitrogen from different feed raw materials can vary considerably. If the feed contains abundant albuminous substances, part of them are used as a source of energy by the fish and not solely as a source of necessary amino acids. A large amount of nitrogen is liberated during the breaking down of amino acids. The degree of phosphorus uptake varies according to the different raw materials between 30 and 80% (Brown & Gratzek 1980). When developing a non-polluting feed, the quantity and quality of fishmeal (the source of protein) are of main importance. In the case of lake water, a feed is needed which contains plenty of fishmeal with a low content of phosphorus, which results in good growth and feed coefficient, combined with a small phosphorus load. In brackish water, another kind of feed is needed. The content of phosphorus in the fishmeal plays a minor role while, on the other hand, the proportion of meal in the feed mixture is of crucial importance. The loading effects of nitrogen are considerably decreased if the albuminous substance content can be lowered and the fats and carbohydrates raised without impairing the growth.

Quantity of waste feed and feed coefficient may, in the case of fresh feed, differ from what has been stated above. It is, however, clear that feed has a crucial influence on the extent of the nutrient load in marine areas as well. If we look

only at the direct loading effects of the biochemical oxygen demand (which in marine conditions possibly presents the only significant inconvenience), fresh feed and dry feed should probably appear in another order. It is not possible, on the basis of a theoretical calculation, to recommend an immediate changeover to fresh feed. This could entail new and unexpected problems, such as hygienic shortcomings, a possibly deteriorated quality of fish products, or similar. In any case, it must be emphasized that research and experimental work are urgently required to clarify these questions.

In case the above theoretical examination proves valid, then it is not worth while, in view of water protection, to develop methods for collecting and treating sludge from net basin farms in brackish water. As far as the lake area is concerned, a condition for using net basin fish farms would presently be that the questions concerning water protection be solved in a satisfactory fashion. The solutions could include some kind of funnels constructed under net cages (Lewis & Wehr 1976) or possibly a replacement of the net, in part (Polhausen 1983) or wholly, with a plastic cloth. These solutions are also associated with possibilities of stimulating production through improved regulation (temperature regulation, drug treatment baths etc.). The type of structure where the basins consist of floating "bags" would, as a cheap design, probably represent the best future solution for expansion of fish farms in the lake area.

Table 2. The theoretical loading effects of phosphorus caused by fresh feed as compared to dry feed.

Feed	Feed co-efficient	Content of phosphorus in feed %	Theoretical loading effects of phosphorus per produced kg of fish[1]
Dry feed	1.8	1.3	19.4
Dry feed	1.3	1.0	9.0
Fresh feed	5.5	0.4	18.0

[1] Excluding the part bound in the fish itself.

Conclusion

A solution of the environmental problems of fish farming in marine areas still requires a great amount of investigative work. The research results which have been obtained in the lake area can not directly be applied to the different natural conditions of brackish water. The ecosystem in the Baltic Sea should be considered in its entirety, and the efforts within research and water protection should be adapted accordingly. The Swedish National Research Council has calculated that the planned fish farming within the Swedish Baltic Sea area, with a yearly production of 4000 tons by 1990, would increase the phosphorus load with 0.24% and the nitrogen with 0.04% (Ackefors et al 1982). The load is exceedingly small when the entire Baltic Sea area is taken into account, but local problems can still occur. Water protection efforts aiming to reduce the difficulties associated with net cage facilities in the marine area will obviously not succeed just by technical improvements in the collection of sludge. On the other hand, it is of

Table 3. Significance of various factors in reduction of loading effects; an example of two plants with a yearly production of 100 tons.

		Plant I		Plant II	
Phosphorus content of fish		0.4%		0.4%	
Nitrogen content of fish		3.0%		3.0%	
Feed coefficient:					
- dry feed		1.8		1.2	
- fresh feed		6		4	
Nutrient salt content of feed and annual nutrient salt quantity in feed :					
- dry feed:	phosphorus	1.5%	2.700 kg	1.0%	1.200 kg
	nitrogen	8.0%	14.400 kg	6.0%	7.200 kg
- fresh feed:	phosphorus	0.4%	2.400 kg	3.0%	3.600 kg
	nitrogen	3.0%	5.400 kg	0.4%	1.600 kg
Collection of sludge to 100% in plant II, load reduction kg/year :					
- dry feed:	phosphorus				400 kg
	nitrogen				640 kg
- fresh feed:	phosphorus				600 kg
	nitrogen				120 kg
Theoretical load of nutrient salts kg/year[1)]					
- with dry feed:	phosphorus		2.300 kg		400 kg
	nitrogen		11.400 kg		4.560 kg
- with fresh feed:	phosphorus		2.000 kg		1.200 kg
	nitrogen		2.400 kg		480 kg

[1)] calculated according to the formula:

R = (RFxAPxFC - APxCF)xRSL, where

R = the theoretical nutrient salt load

RF = nutrient salt content of feed $\%x10^{-2}$

AP = yearly production (100 tons in the example)

FC = feed coefficient

CF = nutrient salt content of fish $\%x10^{-2}$

RSL = Reduction coefficient caused by sludge collection, for phosphorus 0.5 and for nitrogen 0.8

great importance that feed manufacturers, authorities and fish farmers cooperate in order to prevent damage .

To limit the growth of fish farming altogether as a factor injurious to the environment and water protection is in my opinion an exaggerated action. It is possible, through suitable measures, to promote a multi-faceted use of the archipelagic nature in a manner which satisfies all parties. Fish farming in the marine area constitutes a productive, economically sound and growing industry. A comprehensive examination of its energy economics has shown that farming of salmon in net cages is 20 % more profitable than conventional salmon fishing as a method of producing salmon for consumer consumption (Adling 1981).

Literature

ADLING, L., 1981: Energy flows at fish farms and in salmon fishing in the Baltic Sea. Report STU. ref. in: Fish farming and Technology, National Research Council committee report 82:12, 90 p.

ANONYMOUS, 1982: Water usage for Sweden. Proposal for measures. - Report by the steering committee for water usage, compiled by H. Ackefors Et.al., National Research Council committee 82:14.

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